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LARGE BUBBLE CHAMBER

THE NATIONAL BUREAU OF STANDARDS is assisting the University of California Radiation Laboratory in the development of a liquid hydrogen bubble chamber more than 60 times as large as any now in use. The bubble chamber is being constructed to operate with the Bevatron, the six billion electron volt particle accelerator at UCRL. D. B. Chelton, D. B. Mann, and B. W. Birmingham of the NBS Cryogenic Engineering Laboratory at Boulder, Colorado, are working on the project, which involves many difficult and unique cryogenic engineering problems.

Progress in high-energy nuclear physics during the past 20 years has been made possible largely by improvements in particle accelerator design, coupled with corresponding advances in the art of particle detection. The bubble chamber, a new invention in the particle detection field, was devised to overcome some of the shortcomings of the cloud chamber, photographic emulsions, and other detection equipment available for high-energy experiments.

The bubble chamber is a vessel filled with a transparent liquid which can be so greatly superheated that an ionizing particle moving through the liquid will start violent boiling, initiating growth of a string of bubbles along its path. The bubbles, photographed a short time later, while they are still very small, give a clear picture of particle tracks.

In fundamental particle physics pure liquid hydrogen is an excellent target material for the bubble chamber because it has a high nuclear density at low pressures and its simple nucleus provides elementary particle interactions. A reaction taking place in a mass of hydrogen avoids the confusion that may arise when a high-energy particle strikes a heavy nucleus.

However, the operation of a bubble chamber with liquid hydrogen involves complex cryogenic problems. At normal atmospheric pressure, hydrogen boils at 20° K. Its critical temperature is 33° K and its critical pressure is 13 atmospheres, above which no liquid phase is possible. For a hydrogen filled bubble chamber to operate successfully, the temperature and pressure must be between these values.

Successful hydrogen bubble-chamber operation has shown that for best results the liquid should be maintained in the subcooled state at about 27° K and 6 atmospheres. To make the chamber sensitive to ionizing particles, the liquid must be superheated, and this is accomplished by suddenly reducing the pressure to 2 or 3 atmospheres. A significant expansion of the liquid hydrogen volume is required for the

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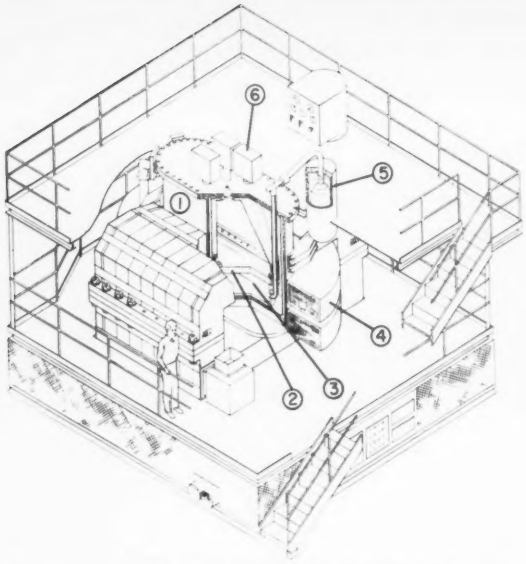
NBS Participation in International Geophysical Year



Prospective drawing of the bubble chamber and magnet assembly now under development by the Bureau and the University of California Radiation Laboratory. Shown are bubble chamber vacuum tank (1), 5-inch-thick glass viewing window (2), liquid hydrogen chamber (3), magnet (4), bubble chamber superheating system (5), and cameras (6).

superheating operation because of the compressibility of the liquid. After photographs of particle tracks are taken, the cycle is completed by compressing the chamber liquid and returning it to the subcooled state. Refrigeration is required to maintain the chamber liquid at a constant temperature because the irreversible superheating process adds energy to the liquid hydrogen.

One-half liter and eight-liter liquid hydrogen bubble chambers have been constructed and operated during the past 2 years at UCRL. The Bureau assisted UCRL with some of the cryogenic design aspects of these smaller chambers, and these early successes led to the belief that a very large liquid hydrogen bubble chamber was feasible. Consequently, a chamber having a volume of about 550 liters (15 x 20 x 84 in.) was planned for use with liquid hydrogen and is now being constructed. It is scheduled for operation early in 1958.

The chamber will have a 20 by 72 inch-long window with good optical properties for observing and photographing particle tracks. The window is to be 5 inches thick to withstand the 6-atmosphere internal pressure of the chamber. An extensive investigation of the low-temperature mechanical properties of glass conducted by R. H. Kropschot and R. P. Mikesell [1] of the Cryogenic Engineering Laboratory made possible the engineering design of this window.

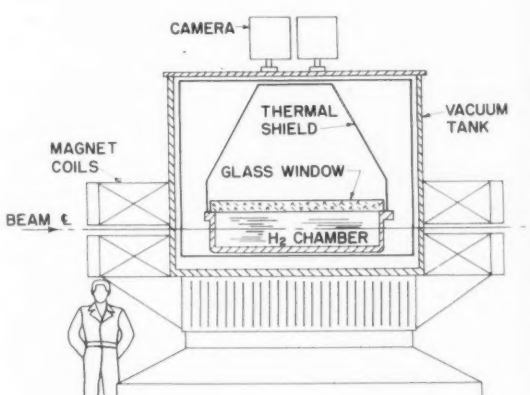
One of the advantages of the bubble chamber as a high-energy particle-detection device is that it can be pulsed (i. e., superheated) at the same rate as the accelerators. However, this pulsing, as previously mentioned, is irreversible and adds energy to the liquid. Thus refrigeration is required if a constant bubble chamber temperature is to be maintained. The refrigerator for use with the 550-liter hydrogen chamber must remove energy at 27° K at the rate of about 1,300 watts when the Bevatron is operating at the maximum pulse rate of 10 per minute.

The hydrogen refrigerator will utilize the Joule-Thomson process and operate at a pressure of 2,000 psig. Two hundred standard cubic feet per minute of hydrogen gas will be circulated in the refrigerator. When there is no refrigeration demand, the unit can be operated as a liquefier producing 60 liters per hour of liquid normal hydrogen.

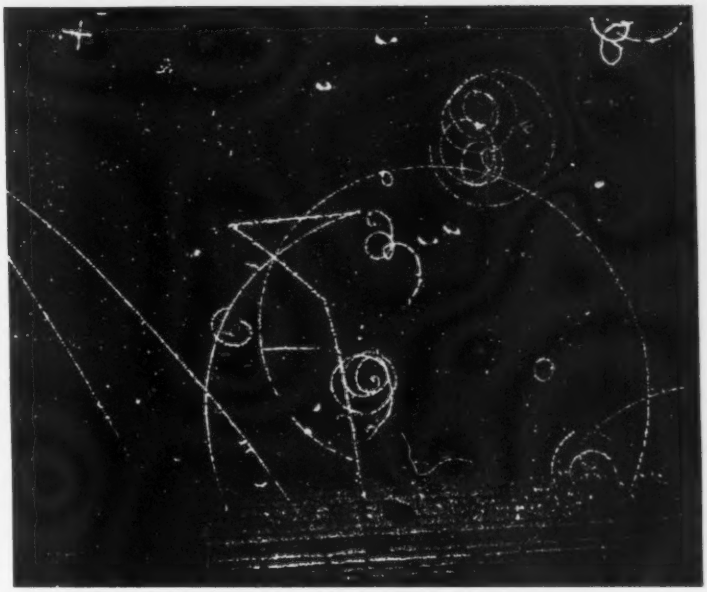
Superheating the liquid hydrogen in the chamber will be accomplished by suddenly expanding the hydrogen vapor in equilibrium with the liquid. Recompression will take place less than 30 milliseconds later when hydrogen vapor maintained at liquid-nitrogen temperature (77° K) is admitted. If the expansion and compression could be accomplished in the liquid phase, the energy input per pulse would be reduced as well as the refrigerator requirements but a complex mechanism operating at 27° K would be required. The vapor expansion system is desirable because it will operate external to the chamber, thereby eliminating a low temperature mechanism. It can then be serviced without requiring a warmup of the bubble chamber.

Whenever possible it is desirable to avoid warming up the bubble chamber because the large glass window must be cooled and warmed slowly to minimize the possibility of breakage. It has been estimated that about 1 week will be required to warm the chamber to ambient temperature and cool it again to the operating temperature of 27° K.

High-energy physicists are anxiously awaiting the completion of this large bubble chamber. Of great



Cross section of proposed bubble chamber and magnet now under development by the Bureau and the University of California Radiation Laboratory.



Patterns produced by events involving fundamental particles in a large hydrogen bubble chamber. Photo courtesy of University of California (at Berkeley) Radiation Laboratory.

interest to scientists was a recent announcement by UCRL physicists that small bubble chambers have shown the existence of a fusion reaction catalyzed by mesons. It is hoped, therefore, that successful operation of the large chamber will make possible a better understanding of fundamental nuclear physics.

[1] An experimental study of the strength and fatigue of glass at very low temperatures, by R. H. Kropschot and R. P. Mikesell, J. Appl. Phys. **28**, No. 5 (1957).

Neutron Calibration Service

THE BUREAU now provides a calibration service for laboratory standard neutron sources. By calibration and certification of such standards, accuracy and intercomparability are promoted in the measurements of neutron flux that play an important part in current research. The service should be of particular assistance to those concerned with fundamental nuclear experiments, design and control of nuclear reactors, problems of protection from neutron radiation, and industrial applications of neutron beams.

Plutonium-beryllium (α, n) sources, such as those recently cleared by the U. S. Atomic Energy Commission for distribution to educational institutions, will be calibrated against the NBS standard plutonium-beryllium (α, n) source in a 4 x 4 x 6-ft graphite column using a boron-lined proportional counter to detect the thermalized neutrons. Other types of neutron sources, having different fast neutron spectra, will be calibrated against the NBS primary radium-beryllium (γ, n) source in a $MnSO_4$ bath. This is done by measuring with a dip counter the γ-activity resulting from the activation of Mn^{55} by the thermalized neutrons. This method is practicable only for sources with total yields higher than about 10^6 neutrons/sec.

From 1 to 2 months should be allowed for the calibration of such a laboratory standard. An accuracy of 2 percent or better is attained in comparing the strength of the submitted standard with that of the standard source. The errors in the absolute calibrations of the standard sources themselves vary from 2 to 3 percent.

The NBS neutron physics laboratory also maintains a standard geometry supplying a uniform thermal neutron flux of 4.038 ($\pm 2\%$) thermal neutrons/cm^2-sec for indirect calibration of unknown thermal fluxes by irradiation of foils. The flux increases slowly with time due to the growth of polonium in the Ra-Be (α, n) sources that are used. The flux value quoted above is for January 1, 1957. A fee of $50 is charged for a 5-day irradiation of a foil in the standard flux.

Inquiries regarding neutron calibrations should be sent to the National Bureau of Standards, Neutron Physics Section, Washington 25, D. C.

[1] *For further technical details on the NBS standard neutron sources, see:* Absolute calibration of the NBS photoneutron standard: I, *by J. A. De Juren, D. W. Padgett, and L. F. Curtiss, J. Research NBS* **55**, 63 *(August 1955) RP 2605;* Absolute calibration of the NBS photoneutron standard: II. Absorption in manganese sulfate, *by J. A. De Juren and J. Chin, J. Research NBS* **55**, 311 *(December 1955) RP2635;* Absolute calibration of the NBS standard thermal neutron density, *by J. A. De Juren and H. Rosenwasser, J. Research NBS* **52**, 93 *(February 1954) RP2477. A descriptive summary is given in* Absolute calibration of the national photoneutron standard, *NBS Tech. News Bul,* **39**, 140 *(October 1955).*

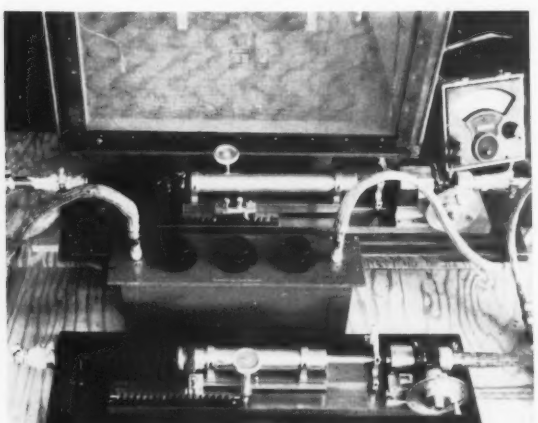
Self-Calibrating Method of Measuring Insertion Ratio

A SYSTEM of measuring insertion ratios with a unique self-calibrating feature is now being successfully used at the Boulder Laboratories of the Bureau.

First originated in March 1953 by C. M. Allred of the High Frequency Electrical Standards Section of the NBS Radio Standards Laboratory, the system gives both the insertion phase angle and the insertion loss of a network. In principle an unlimited accuracy may be approached.

The method does not require attenuators nor other components with known parameters obtained by calibration or computation from a set of dimensions. Because it is a null method of measurement, high sensitivity is achieved and the usual difficulties caused by instabilities in the level of the rf source or in the gain of the monitor are eliminated. Precise and accurate measurements can be made of the change in phase angle and ratio of voltage magnitudes at a point in a circuit as a network is added to or removed from the circuit.

One experimental setup consists of a circuit with three parallel legs connected between an rf generator and a monitor. Two of the legs contain piston attenuators, Y and Z, one of which is in series with a phase shifter, ϕ_1. The third leg contains the unknown network to be calibrated. This network is isolated from the rest of the system by attenuator pads and is in series with a second phase shifter, ϕ_2. The two piston attenuators are of the TE_{11} mode waveguide-below-cutoff type. The phase shifters need not be of precision type as the phase angles need not be known, nor is a corresponding incidental change in level important. A well-shielded stable-frequency generator and a well-shielded sensitive monitor are used.



An experimental setup employing the three-channel null system. The setup can measure the complex insertion ratio of a network, thereby giving both the insertion phase angle and the insertion loss. Using the null principle, the system is insensitive to instabilities in rf source level and monitor gain, and high sensitivity is obtained. The system is unique in that it is self-calibrating, thereby offering a standard of insertion ratio which is not dependent upon external or internal standards of length, mass, and other quantities.

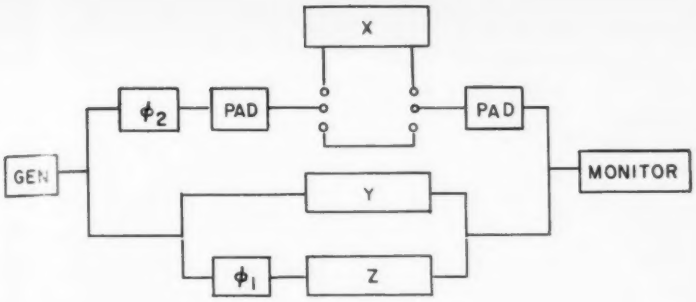
To measure the insertion ration of an unknown network, phase shifter ϕ_1 may be set at any angle, but for easier adjustment it is usually set so that the output voltages of the two piston attenuators are approximately 90° apart. With the unknown network removed and the pads connected together, phase shifter ϕ_2 and the two attenuators are varied so as to produce a null. Noting the readings y_a and z_a of each of two attenuators and without changing either of the phase shifters, the unknown is inserted into the circuit. The piston attenuators are now varied to produce a new null and the new readings y_b and z_b are noted. The insertion ratio, K, of the unknown may then be obtained by substituting the above readings into the following equation:

$$K=\frac{e^{-\gamma_y y_a}+We^{-\gamma_z z_a}}{e^{-\gamma_y y_b}+We^{-\gamma_z z_b}}$$

where γ_y and γ_z are the propagation constants of each of the two attenuators and W a constant of the system expressing the relative phase angle and magnitudes of the output voltages of the two attenuators. These are determined either by computation from known dimensions and properties of materials together with other measurements, or by self-calibration.

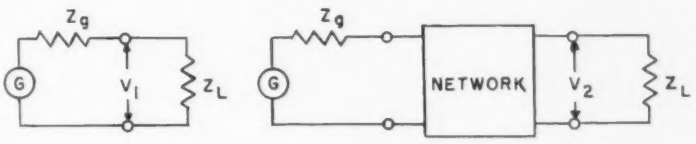
The concept of the self-calibration feature is suggested by the nature of insertion ratios. By definition, insertion ratio is a pure ratio and hence dimensionless. A standard to measure dimensionless quantities should not have to rely upon dimensional standards. An example of such a dimensionless ratio measurement is given by the familiar Lissajous pattern produced by oscillations of two different frequencies.

The insertion ratio of a given network depends only upon its terminating impedances and not upon other parameters of the system. Hence, if the above procedure of insertion ratio measurement were to be repeated after setting the phase shifter ϕ_2 to a different position, two different settings (y_a, z_a, y_b, and z_b)



Left: **Block diagram of the three-channel self-calibrating insertion ratio measuring system used. The two self-calibrated attenuators are *Y* and *Z*. The components ϕ_1 and ϕ_2 are used for phase adjustments. Knowledge of the phase shift and incidental level changes is not important. The phase shifter ϕ_1 is adjusted before calibration and thereafter remains unchanged. The phase shifter ϕ_2 is used in the process of self-calibration. The pads are attenuators used for impedance matching and isolation of the unknown or X network.**

Right: **Diagram illustrating the insertion ratio of a network. The insertion ratio is defined as $K=(V_1/V_2)$, where V_1 and V_2 in general are complex quantities, or in polar form, $K=pe^{j\theta}$. The insertion phase angle is θ and the insertion loss, expressed in decibels, is 20 log p.**

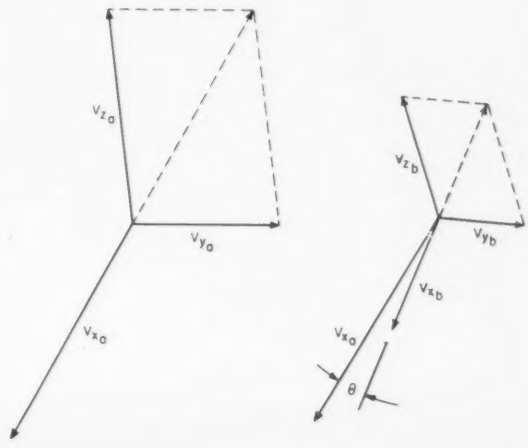


would be found for the two attenuators. The preceding equation applies, and these readings would yield the same insertion ratio for the unknown as before. Therefore, by changing ϕ_2 to other positions, a number of simultaneous equations may be obtained. These equations may then be used to solve for the unknowns, γ_y, γ_z, and W. The preceding equation applies to piston attenuators operating in a single mode. With additional modes or with other types of continuously variable attenuators, a larger number of constants may be required to describe the system. The values of these constants are obtained in the same manner as before. Thus, the attenuators may be calibrated by requiring self-consistency with a given unknown network. The latter is measured by the system once calibration has been completed.

Although other types of attenuators may be used, piston attenuators offer some desirable characteristics because they are generally specified by only two parameters, the attenuation constant and the phase constant (normally a very small quantity). Also, the output of a piston attenuator operating in the TE_{11} mode may be changed 180° without level changes by rotating either the launching or receiving coils 180°. This is desirable because when the angle between the *Y* and *Z* attenuators is 90° or greater, voltages with phase angles of any value can be nulled if either of the output voltages of the attenuators is changed by 180°.

Whereas in principle an unlimited accuracy may be approached, in practice the accuracy of the system is limited by a number of factors such as the number of parameters to be calibrated, the ratio of signal to noise, stability of the unknown network used for calibration, stability of various components of the system, and the precision of readings taken from the attenuator settings. There are also some minor restrictions on the "X" network when it is to be used to calibrate the system.

The major advantages of the system are (1) the use of the principle of self calibration, which may be used to eliminate errors that are difficult to impossible to ascertain by other methods, (2) its ability to measure the angle as well as the magnitude of the insertion ratio, (3) the application of the null method, resulting in higher sensitivity and precision as well as freedom from effects of rf source level and monitor gain instabilities.



Simplified vector diagrams illustrating the two nulls of the three-channel system when the unknown network is out of or in the circuit. V_y and V_z are the output voltages from the two piston attenuators, and V_x is the output voltage of the unknown network. Their values are used to determine the insertion angle, θ, and the insertion loss,

$$20 \log \frac{V_{xa}}{V_{xb}} \text{ db.}$$

Small Fire Extinguisher Tests

AS THE RESULT of an investigation to develop improved test methods for fire extinguishers suitable for flammable liquid fires, the Bureau has determined the relative fire-fighting effectiveness of several small hand-portable extinguishing devices. Sponsored by the U. S. Coast Guard, the research was conducted by H. Shoub, T. G. Lee, J. Loftus, and J. M. Cameron.[1] The study also resulted in ascertaining the effects of five extinguishig agents on 10 types of fires.

Since 1914, the Bureau has carried on an extensive program of research and development in the field of fire protection. Studies have included ignition phenomena and fire resistance of materials, flame detection and extinguishment, and fire growth and spread.[2] A portion of this program revealed wide variations in the performance of small fire extinguishers; thus, the demand for efficient extinguishers for use on small motorcraft led the Coast Guard to make funds available for an evaluation of devices and agents in use. As a result of this work, more significant criteria for extinguisher suitability have been proposed.

The five agents tested included two vaporizing liquids (carbon tetrachloride and chlorobromomethane), carbon dioxide, dry chemical (bicarbonate of soda treated with a moisture repellent), and foam. These agents were discharged by 15 extinguishers. Eight were vaporizing liquid devices, of which 4 were hand pumps and 4 were dependent on gas pressure stored in the charge chamber. The other 7 included 3 carbon dioxide extinguishers, 2 stored-pressure dry chemical extinguishers, a dry chemical extinguisher with its expelling gas contained in a cartridge, and a foam extinguisher.

Extinguisher trials were made on 10 different types of fires. Three of these fires—a fuel spill on a fixed area, fuel-saturated cotton waste, and fuel in a small tub—have been standard tests of extinguishers for flammable liquids. For more exhaustive trials, the Bureau included fires in partially enclosed spaces, with or without an obstacle to the free dispersal of the extinguishing agent. The space consisted of a metal compartment in which changes in the opening could be effected by removing the end plates and top. The obstacle was a closed metal box placed in the center of the compartment. In addition, three other types of possible hazards were simulated, including fire in an open shallow pan, fire in a leaking container, and a spill flowing over a vertical surface.

Because the extinguishers compared were all intended primarily for flammable-liquid fires, heptane, a fuel similar to gasoline, was used in all but one type of fire. Heptane, which has a narrow distillation range, provided reproducible conditions of fuel consumption as well as fair burning equilibrium. To introduce the effect of another fuel on extinguisher performance, alcohol was used in the vertical spill fire. In some tests wood was introduced to provide a means of determining the extinguisher effectiveness on mixed fuels.

Five trials made with the 15 extinguishers on each of the 10 fire types provided sufficient data for significant statistical analysis of results. Data included observations of weather conditions, such as temperature, wind velocity, barometric pressure, and humidity. Temperatures of the fuel and extinguisher, the method of attack, and the amount of extinguishing agent expended were also noted. Experiments were programed so that the intercomparison among extinguishers would not be affected by differences in weather conditions changing with time. However, the relative success in different tests of a particular extinguisher on a particular type of fire was somewhat affected by these variables.

Application of a vaporizing liquid extinguisher to a partially enclosed fire.

As a means of evaluating the results, a score was assigned to each trial. An arbitrary rating system was established, based on six levels of success ranging from +3 to −3. Plus scores denoted cases where the fire was extinguished, the highest number indicating easiest accomplishment; minus numbers denoted failures, −3 representing lowest efficiency. While the plus ratings were usually based on the conservation of extinguishing agent, the negative scores were assigned on the basis of the observers' judgment of the degree of failure.

In 94 of the 150 possible arrangements of fire and extinguisher types, all five trials are in agreement on

the success or failure of extinguishment. One inconsistent run appears in 30 groups while the remaining 26 groups are split three-and-two.

Analysis of the data reveals that fire configuration greatly influences the effectiveness of a particular extinguisher. Confining surfaces provide favorable conditions for efficient extinguisher action as the agent accumulates to a concentration necessary for putting out the fire.

Although the fire-test program was conducted under a wide variety of ambient conditions, the results do not show appreciable influence of any individual measured factor, with the exception of wind speed. The degree of wind sensitivity depends more on the fire type than on the type of extinguisher.

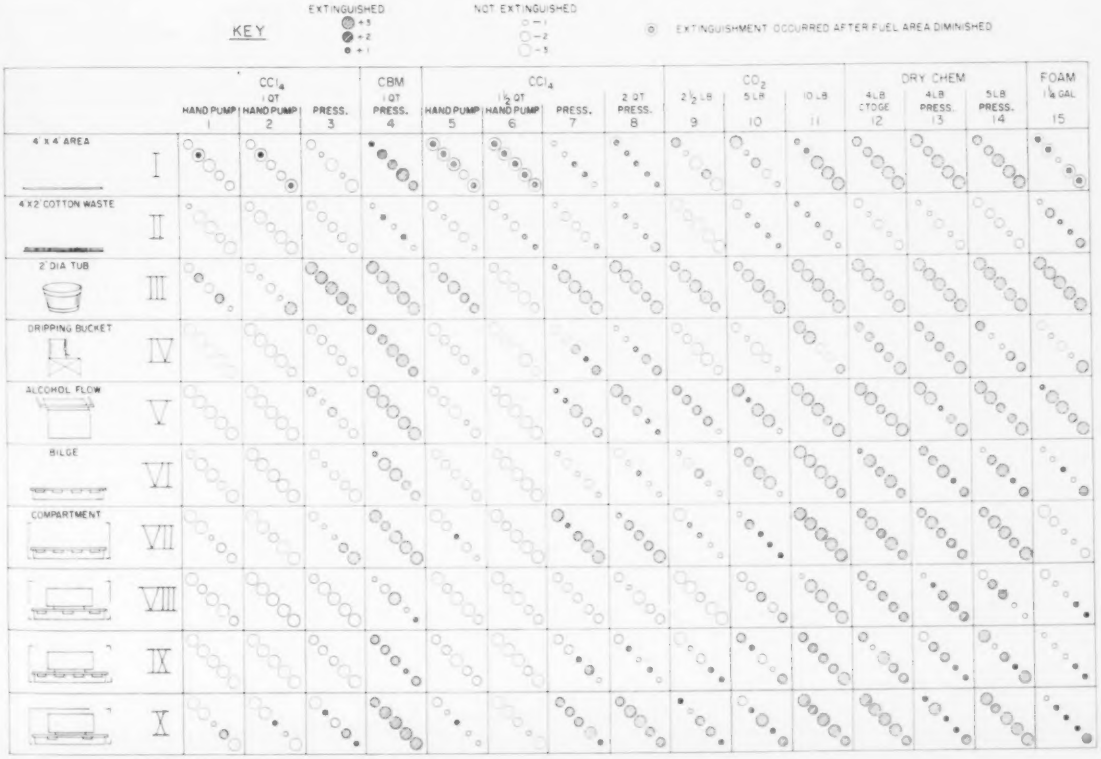
Observations showed that the methods of attack yielding optimum results vary with the fire model and particularly with the extinguisher. Generally, carbon tetrachloride is best employed by spraying on a hot surface to secure maximum vaporization, and in such a manner as to cover the area with the decomposition products. Dry chemical extinguishers are most effective when operated to cover the whole flaming area at once. Carbon dioxide types seem to work best when the agent is discharged in a sweeping motion near the fuel surface. Foam is effective only if it can be made to flow directly onto the burning-liquid surface. A high rate of discharge in any particular type of extinguisher enhances the effectiveness of the performance.

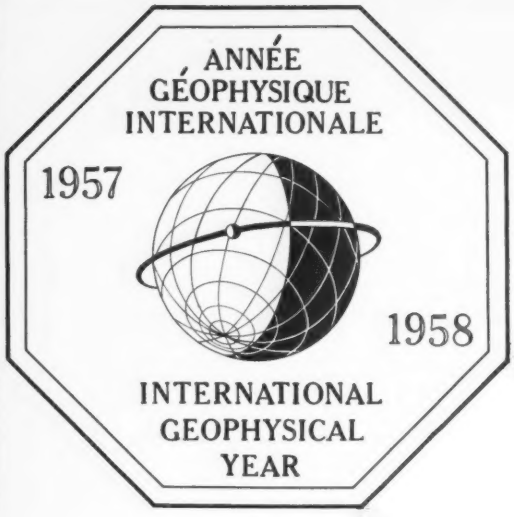
Extinguishers of the type of the 1-qt chlorobromomethane, 10-lb carbon dioxide and 4-lb dry chemical devices used in the tests rank very closely in usefulness on the test fires, and generally would be superior to the other types of extinguishers of this program on flammable liquid fires of limited extent.

[1] Methods of testing small fire extinguishers, *by H. Shoub, T. G. Lee, and J. M. Cameron, NBS Building Materials and Structures Report 150. Copies may be purchased from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. for 15 cents.*

[2] Fire Protection research at NBS, *NBS Tech. News Bul.* **41**, *40 (March 1957)*.

Five trials were made with 15 extinguishers on each of 10 fire types. This schematic chart illustrates the performance obtained with the extinguishers. The key to interpretation of the diagram is based on six levels of success: the highest positive number (+3) indicates easiest extinguishment and the lowest negative number (−3) represents minimum efficiency.





NBS Participation th

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THE NATIONAL BUREAU OF STANDARDS is playing an active, many-faceted role in the International Geophysical Year of 1957–58. From observation stations widely scattered over the globe, the Bureau is collecting and analyzing data on many phases of upper atmospheric physics and radio propagation. Centered in the Boulder (Colo.) Laboratories, where most NBS radio propagation research is carried on, the Bureau's part in the program includes studies of the ionosphere, forward scatter propagation, various kinds of radio noise, airglow, and related phenomena. The results, when analyzed and correlated with those obtained elsewhere, are expected to provide valuable information in such fields as meteorology and radio communications.

During the IGY, which began July 1 and will continue through December 31, 1958, several thousand scientists representing some 60 nations will make simultaneous worldwide observations of the earth and its immediate cosmic environment. The data gathered in this huge cooperative measurement program should help answer question regarding the size and shape of the earth, the origins of earthquakes, the causes of radio blackouts, the sources of weather disturbances, and many other earth phenomena.

United States participation in the IGY program [1] is planned and directed by the U. S. National Committee, which was organized by the National Academy of Sciences—National Research Council and is under the chairmanship of Dr. Joseph Kaplan. Alan H. Shapley, Chief of the NBS Sun-Earth Relationships Section, is Vice Chairman of the U. S. National Committee and one of the three American scientists who are members of the international committee (Comité Special Année Géophysique Internationale). Dr. Allen V. Astin, Director of the Bureau, and Dr. Lyman J. Briggs, Director Emeritus, are also members of the U. S. National Committee. A number of other staff members [2] are providing professional guidance or technical advice to the IGY. More than 100 NBS scientists and technicians are engaged in work that is part of the over-all IGY plan, including both projects of many years' standing and new experiments undertaken specifically for the IGY.

Ionospheric Studies

The greatest part of the Bureau's effort will be concerned with variations in the ionosphere, the electrically charged region of the upper atmosphere 25 to 250 miles above the earth. By reflecting radio waves the ionosphere makes possible long-distance transmission between such points as New York and London. Changes in the various layers of the ionosphere greatly affect the quality of long-range reception in different frequency ranges.

Because of its extensive studies of the ionosphere as a factor in radio propagation, the Bureau has been given responsibility for the ionospheric data program in the Western Hemisphere. In this program information is collected from numerous laboratories making observations of the ionosphere and added to that obtained by the Boulder Laboratories. These data will be made available to research scientists of the Americas as well as to the other world-data centers in Moscow, Tokyo, and Slough, England.

At all times the ionosphere is greatly affected by solar activity. At present, the 11-year sunspot cycle is entering a peak phase, and for the next year or so the sun will be sending out gigantic flares of intense light from time to time. Thus the earth's upper atmosphere will be attacked by vastly increased barrages of ultraviolet radiation and streams of atomic particles. The results will be ionospheric disturbances with shortwave radio blackouts. In the high latitudes of the Northern and Southern Hemispheres the ionosphere may even be expected to fail completely as a reflector of radio waves for several days at a time.

During this period of intense ionospheric activity, IGY scientists hope to gather enough information

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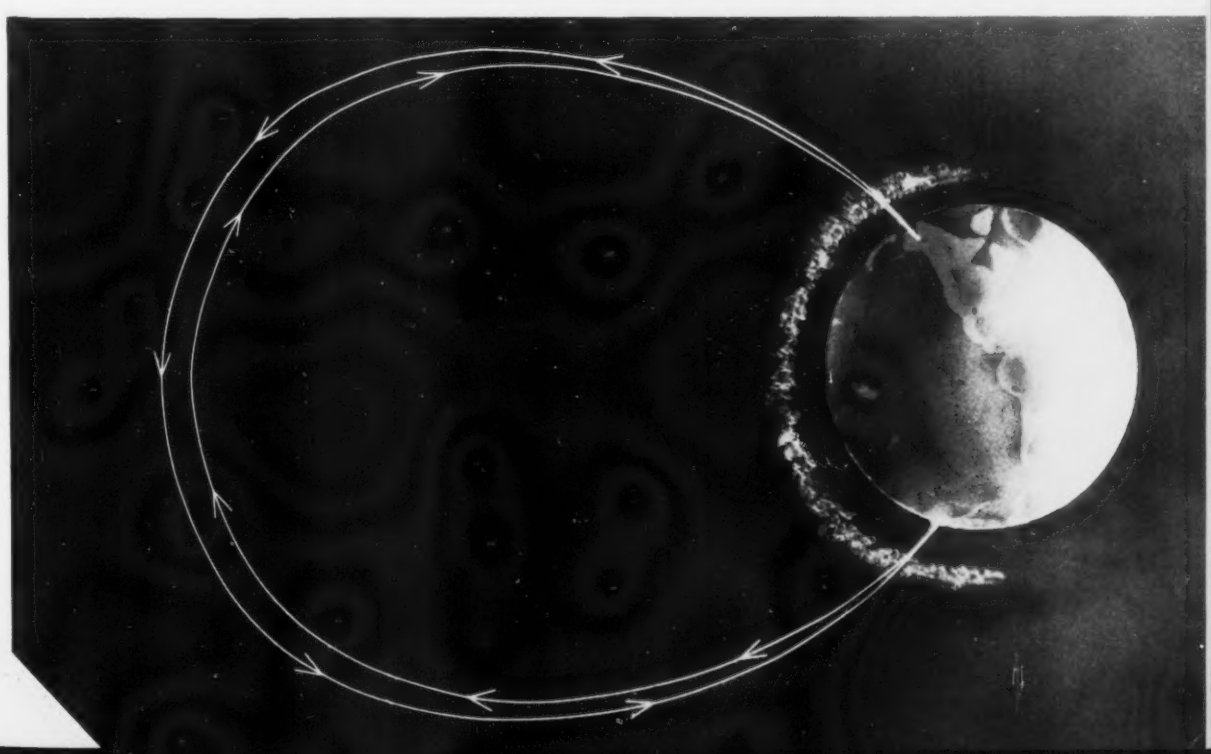
about the ionosphere so that much improved predictions of radio propagation conditions can be made. The ionospheric studies will consist mainly in soundings of the various layers of this region. The Bureau is directly concerned with some 37 of the almost 200 stations scattered throughout the world that will be making vertical soundings of the ionosphere. These are radio research stations which transmit radio pulses of various frequencies beamed at the ionized layers. The round-trip time of the reflected signal is noted, and by means of complex calculations the heights and densities of the reflecting layers can be determined. Simultaneous data gathered by all the stations will be plotted and analyzed to provide a global picture of the ionosphere and its properties.

The Bureau is equipping and maintaining 19 new stations, carefully located to fill important gaps in the world network. Five of these—the Antarctic sounding stations—will be operated by NBS and the others will be closely guided in their work by Bureau staff members. The pre-IGY network of 7 NBS-operated and 11 associated stations will continue through

Drawing illustrating the production of whistlers, a special kind of natural radio signal in the audio and very-low-frequency range.



Drawing showing the ionosphere in relation to the earth. Actually the ionosphere is not a visible phenomenon since it is composed of ionized air. It occupies that part of the upper atmosphere between 25 and 250 miles above the earth's surface.

the IGY period. The Bureau also plays an important role in the international organization and coordination of the ionospheric soundings program. Members of the staff were authors of the recently published 150-page IGY instruction manual and an extensive atlas of typical records, which will be invaluable in the attempt to obtain consistent and comparable observations from the world network.

One of the outstanding mysteries in the propagation of radio waves by the ionosphere is the phenomenon known as sporadic-*E*. Very high frequencies, such as television and FM signals, ordinarily pass through the ionosphere into space without reflection. Sometimes, however, these signals are reflected spasmodically and erratically back from highly ionized patches in the ionosphere, and are heard over distances of more than 1,000 miles. This phenomenon is called sporadic-*E* from its uncertain nature and from that fact that reflection takes place in the *E*-layer of the ionosphere. As part of the IGY program, the Bureau will intensify its study of sporadic-*E*, operating carefully controlled circuits in the Far East, South America, the Caribbean, and the United States.

Scatter Propagation

Forward scatter—a recently discovered mode of radio propagation—promises to extend greatly the limits of long-distance communication in the VHF region. In ionospheric forward scatter, small but useful amounts of radio energy are returned to the earth by a scattering mechanism when high-powered transmissions are beamed at the ionosphere. Considerable interest has been shown in obtaining reliable radio communications over long distances in this way.

In cooperation with several South American laboratories, the Bureau will conduct research into ionospheric forward scatter in the equatorial region. Seven stations are being set up near the equator for this purpose. Ionospheric scatter has been studied at arctic, subarctic, and temperate latitudes, but these will be the first experiments carried on near the equator. The stations will transmit northward across Central and North America and eastward across South America. Further investigations of ionospheric scatter will be made in the Caribbean area in cooperation with the Navy and in the Far East in a cooperative program with the Voice of America and the Japanese Radio Research Laboratories.

Adjusting the operating frequency of an ionospheric recorder at a Bureau field station. The time required for radio waves to reach the ionosphere and return is measured and recorded—approximately one thousandth of a second. With the frequency increasing in steps, a range from 1 to 25 Mc is covered in 15 sec. The entire process is repeated automatically to give a continuous record which reveals much about the height and characteristics of the ionosphere.

Radio Noise

The Bureau will play an important part in the IGY study of radio noise. Here the objective will be to learn more about radio interference and propagation through the atmosphere and ionosphere. Sixteen worldwide stations for noise observations have been set up in cooperation with other United States agencies and other countries. One American station is at Byrd Station in Antarctica: others are in Hawaii, Greenland, and the Canal Zone, as well as the continental United States. NBS equipped stations operated by foreign countries are in South Africa, Ghana, Morocco, Australia, Brazil, Malaya, India, Sweden, and Japan. All data from the various stations will be forwarded to the Boulder Laboratories for analysis.

The results of this study will not only provide valuable information about radio propagation and meteorology but will also establish an engineering basis for assigning frequencies to stations. For the commercial and military radio users who must know which frequencies are best for use at a given time and place, forecasts will be made of the amount of unwanted noise that will interfere with their communications. With other information provided by the Bureau, they will be able to tell the minimum transmitter power that can be used to get their information to the receiver in spite of competition from noise of natural origin.

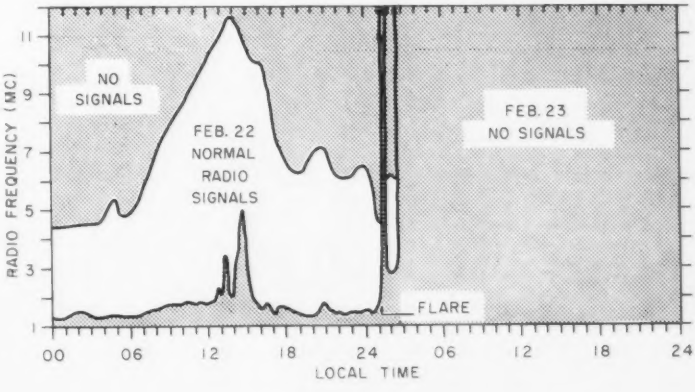
Whistlers

Near Boulder the Bureau has stretched a steel cable for 3,400 feet over a canyon, under 9,000 pounds tension. This cable will serve as a huge antenna to catch naturally occurring radio noises known as "whistlers" and the "dawn chorus." Whistlers are low-frequency signals initially generated by lightning discharges. The resulting radio wave is reflected back and forth between the Northern and Southern Hemispheres, following the earth's magnetic lines of force at heights up to 25,000 miles. The whistler radio wave is a mixture of tones that arrive at different times and create a descending whistle effect. Other radio noises that ascend in pitch, resembling the sound of small frogs, have received the name of dawn chorus.

While a rocket can gather information about the ionosphere only up to about 250 miles, a study of whistlers can give clues to the properties of space 100 times farther away from earth. The Bureau has participated in pioneering research studies on whistlers. It will operate 3 of the 26 stations that will be gathering data under the guidance of Stanford University and Dartmouth College, the United States coordinators for this program.

Airglow

The Boulder Laboratories, together with a chain of cooperating foreign and domestic stations, will systematically record the intensity of airglow, a faint night-sky luminescence.



Graph showing how radio communication is completely blocked out when the sun sends out a great burst of light called a flare. Ionization is seen to increase drastically in the lower part of the upper atmosphere absorbing instead of reflecting radio waves.

Airglow is so faint that it is rarely visible to the naked eye. However, telescopic photometers have been developed which measure the airglow in the light of red and green radiation emitted by oxygen atoms, yellow wave lengths emitted by sodium atoms, and infrared due to the OH radical. The Bureau will operate two airglow observing stations using this type of photometer. It has supplied five such photometers to others in the American chain of 13 stations which runs from Thule, Greenland to San Juan, Argentina. International cooperation is essential in these investigations since the study of worldwide variations in the intensity of airglow is an important part of the IGY program.

The Boulder Laboratories will serve as the data processing center for analyzing and measuring airglow records supplied by the American chain of observing stations. For purposes of comparison, data will also be sent in from a station in another longitude—at Sydney, Australia. The results from these stations

will be correlated with those obtained by other foreign countries. When studied together with the findings of other IGY upper atmosphere programs, it is hoped that airglow data will reveal information about the composition, temperature, and dynamics of the upper atmosphere.

World Warning Agency

The day-to-day coordination of a large part of IGY observations is accomplished through the most extensive communication network ever arranged for scientific research purposes. The designation of special days and intervals for special or intensified effort by IGY stations will help assure that the right kinds of observations are taken while the extensive IGY networks are in operation.

Focal point of the system is the Bureau's radio forecasting center near Washington, which has been selected as the IGY World Warning Agency[3] by the international IGY committee. From this nerve center of the whole IGY program, located at Fort Belvoir, Virginia, warnings are flashed to scientists throughout the world to redouble their observational efforts in anticipation of unusual activity in cosmic rays, aurora, earth magnetism, and ionospheric disturbances.

The warnings are based mainly on observations of the surface of the sun which is under 24-hour surveillance by cooperating observatories all around the world. Warnings are of two kinds: Alerts and Special World Intervals. When reports justify it, the staff of the World Warning Agency issues an Alert, advising scientists that a Special World Interval may be called within a few days. If a strong disturbance appears likely within 24 hours, the Special World Interval is announced on 8-hours' notice. During the Special World Interval IGY programs in ionospheric physics, geomagnetism, solar activity, cosmic rays, and aurora are intensified.

Every day hundreds of IGY messages flow in and out of the NBS station at Fort Belvoir. The international communication net involves the radio teletype network supervised by the World Meteorological Organization, virtually all of the commercial communications facilities throughout the world, government facilities (such as military channels and in the United States, the Civil Aeronautics Administration), and special messages broadcast by stations WWV and WWVH (on the NBS radio propagation forecast channels) and their counterparts in other countries.

Data Processing

Much of the IGY program at the Boulder Laboratories will be greatly aided by modern high-speed techniques developed chiefly during the past 10 years. Without them, scientists could scarcely hope to keep up with the processing of the billions of geophysical measurements to be recorded during the next year and a half.

Each member of this chain of stations is making observations of airglow. At a world data processing center on airglow at the Boulder Laboratories, all the collected information will be mapped together to obtain a more definite understanding of the causes of this phenomenon.

The IGY program will increase from 5 to 10 times the normal volume of data handled by the Boulder Laboratories. Equipment has been installed to make the computation of IGY data largely automatic, eliminating hand-processing wherever possible.

A great deal of the IGY information forwarded to Boulder will be recorded on punched cards and stored in fire-proof archives now under construction. Here the data will be kept available and safe for future special research programs. To process the vast sea of scientific data that will come in from 60 ionospheric study stations in the Western Hemisphere and the Pacific area, the Boulder Laboratories will rely on a high-speed electronic computer.[4]

[1] The National Science Foundation is responsible for the Government's fiscal sponsorship of the IGY.

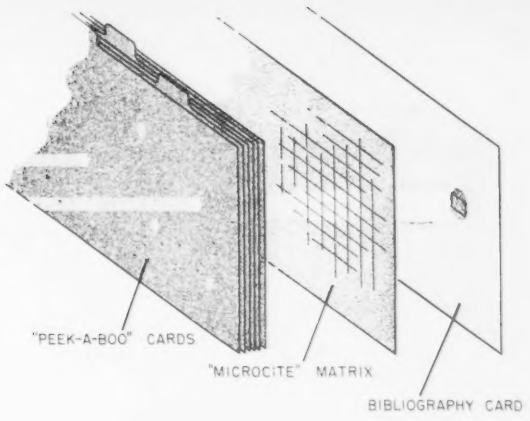
[2] *Dr. F. E. Roach is Vice Chairman of the Technical Panel on Aurora and Airglow; Dr. R. J. Slutz is a member of the Technical Panel on Ionospheric Physics; and A. G. Jean is consultant to this panel; A. G. McNish is consultant to the IGY Technical Panel on Geomagnetism. Mr. Shapley is also a member of the Executive Committee of the U. S. National Committee, the Antarctic and Arctic Committees, and Technical Panels on Ionospheric Physics, Solar Activity, and World Days and Communications. He represents URSI on the CSAGI meetings and is the international coordinator for the IGY World Days program.*

[3] IGY World Warning Agency, *NBS Tech. News Bul.* **41**, 5 (May 1957).

[4] *An IBM 650 is used. This machine is equipped with a magnetic drum memory and can perform 12,000 additions or subtractions of 10-digit numbers a minute.*

MICROCITE

an aid to more effective referencing



MICROCITE, a method for making indexed information directly accessible and reproducible, is being developed to increase the effectiveness of literature searching at the Bureau. Proposed for use in the Bureau's instrumentation reference service, the Microcite feature consists of photographically storing greatly reduced copies of citations and abstracts (called microabstracts) so they can be readily located and read. The Microcite technique was devised by J. Stern to improve searching with the "Peek-a-boo" filing and retrieval system used in the reference service.[1]

The instrumentation reference service maintained by the Bureau was inaugurated several years ago as part of a program on basic instrumentation [2] sponsored by the Department of Defense and the Atomic Energy Commission to help Government scientists obtain existing information on instruments, controls, and data-handling devices without a time-consuming literature search. The information search system used, referred to as "Peek-a-boo," makes use of hand-manipulated punched cards each of which represents an index term such as "electromagnetic," "detection," or "heat." The identity of documents to which the index term applies is noted by punching holes at appropriate locations on the card: the location of a hole is determined by the serial number assigned to the document.

Peek-a-boo cards alined so that coincident holes are illuminated. A filmed matrix overlay allows direct reference reading.

To carry out a search, the investigator removes from the file a number of cards, each labeled with an index term associated with the type of references he is seeking. These cards are placed on a plastic reading illuminator which properly alines them. Any holes common to all the cards will then be seen as small spots of light. In the basic Peek-a-boo system the coordinates of these spots, determined with the aid of a numbered grid, identify the serial numbers of references common to all the selected cards; the serial numbers lead in turn to the actual references sought.

With the Microcite feature added to the Peek-a-boo system, information on the subject of interest appears as a direct result of superimposing the term cards, rather than requiring an intermediate serial number. In one version, the film containing the matrix of microabstracts can be placed over the stack of selected Peek-a-boo cards. The microabstract of each reference occupies just the position in its matrix that would otherwise represent its serial number. The microabstracts can be slightly larger than the serial number holes because no supporting area is needed between images as is required between perforations. A light diffuser between the search stack and the film matrix permits the small index holes to illuminate the larger areas of the microabstract matrix. The information sought can then be read by viewing the illuminated frames under a microscope. In the Bureau's experimental work on the Microcite feature, cards and matrix $3\frac{1}{4}$ by $7\frac{3}{8}$ in. are used with a capacity for 1,000 microabstracts.

With another Microcite technique under consideration, the Peek-a-boo holes would be used only to locate the abstract. Positioning a locating pointer of an automatic readout device at a light spot on the card stack would cause the corresponding abstract to be illuminated and projected for reading. This

arrangement would permit the indicating hole to be very much smaller than a microabstract, and would allow flexibility in distribution of the abstract positions.

For preparing bibliographies in answer to reference questions, the Microcite feature could also eliminate other time-consuming operations. If the film matrix (a negative in this case) were sandwiched between the search stack and a suitable photographic printing paper, light passing through the holes in the card stack would provide illumination for printing the selected references. The time and effort involved in duplicating the information for enclosure in a letter could therefore be avoided by printing directly on a sensitized postal card. In this way the reference information could be made ready for immediate mailing to the inquirer, who could read it on any of several commercially available microimage projectors. Extensions of both the basic Peek-a-boo principle as well as the Microcite feature are being further investigated.[3]

The Microcite technique may be utilized with any system in which documents can be identified by serial number. Because it offers improvement on an already powerful reference tool, the Microcite technique should be of interest to organizations having research libraries, reference services, catalog divisions, or other indexing problems.

Improved equipment for punching and viewing the Peek-a-boo cards has been designed at the Bureau to provide a capacity of 18,000 document numbers with a card size of 5 by 8 in. Interest shown by several manufacturers indicates that equipment of this type may soon become commercially available. However, standard accounting machine cards and a hand punch are adequate for applying the Peek-a-boo principle to small collections.

[1] Instruments reference service, *NBS Tech. News Bul.* **39,** *8 (August 1955).*
[2] Basic instrumentation at NBS, *NBS Tech. News Bul.* **37,** *9 (September 1953).*
[3] Punched cards, *edited by Casey, Berry, Kent, and Perry. Revised edition to be published late in 1957.*

42d National Conference on Weights and Measures

APPROXIMATELY 450 DELEGATES from 38 states, the District of Columbia, Alaska, and Puerto Rico attended the 42d National Conference on Weights and Measures held in Washington during the week of June 3. Representatives from Canada, England, and Indonesia were also on hand as the opening session got under way with addresses by the Honorable Walter Williams, Undersecretary of Commerce, Dr. A. V. Astin, Director of the National Bureau of Standards, and the Honorable Daniel J. Carey, Commissioner of Agriculture and Markets of the State of New York.

Sponsored by the National Bureau of Standards, the National Conference is made up of State and local officials engaged in weights and measures regulatory service and representatives of interested Federal agencies and various manufacturing, commercial, and consumer organizations. One of the highlights of this year's meeting was the adoption of a Statement of Organization and Procedure.[1] Based principally on the experience of the preceding 41 meetings, this is the first document of its kind since the National Conference began meeting in 1905. Among other things in the unanimously adopted Statement, is the following list of objectives:

"(a) to provide a national forum for the discussion of all questions related to weights and measures administration as carried on by regulatory officers of the States, Commonwealths, Territories, and Possessions of the United States, their political subdivisions, and the District of Columbia; (b) to develop a consensus on model weights and measures laws and regulations, specifications and tolerances for commercially-used weighing and measuring devices, and testing, enforcement, and administrative procedures; (c) to encourage and promote uniformity of requirements and methods among weights and measures jurisdictions; and (d) to foster cooperation among weights and measures officers themselves and between them and all of the many manufacturing, industrial, business, and consumer interests affected by their official activities."

The Statement of Organization and Procedure was prepared for the Conference by a special Study Committee on Conference Organization appointed by Dr. A. V. Astin, President of the Conference, subsequent to the 41st meeting in 1956. Adoption of the Study Committee's report has now formalized the organization and procedure of the Conference, including its objectives, relationship with the National Bureau of Standards, constituent membership, officers and committees and their duties and fields of operation, and voting and other procedures.

The Conference was also highlighted by discussions on weights and measures in their respective homelands and jurisdictions by T. G. Poppy, Controller of Standards, Standard Weights and Measures Department, Board of Trade, London, England; R. W. MacLean, Director of Standards, Ottawa, Canada; A. E. Diaz, Head, Weights and Measures Division, Commonwealth of Puerto Rico; and R. A. Findlay, Deputy Inspector, Territory of Alaska.

An innovation was the holding of an open forum on administrative problems, for which an entire half-day session was set aside. To introduce specific topics during this open forum, speakers presented brief, informal talks under the following titles: *Relations Between State and Local Departments, Relations Between the Official and Manufacturers and Dealers in Weighing and Measuring Devices, Enforcement of Package-Marking Requirements, Exchanging Information with*

Other Officials, and *Justification of Budget Increases*.

The Bureau presented to the Conference a discussion on the testing of liquid-measuring devices for liquefied petroleum gas. The discussion included a description of the Bureau-designed testing equipment and an explanation of a simple testing and operating procedure developed at the Bureau. The significance of this development is considered substantial because, through procurement of the equipment and adoption of the procedure by the States, official control will be exercised for the first time over the thousands of positive displacement meters used commercially for dispensing liquefied petroleum gas.

Officers of the Conference for the ensuing year include Dr. A. V. Astin, *ex officio* President, W. S. Bussey (Chief, NBS Office of Weights and Measures), *ex officio* Secretary, and the following who were elected: Chairman, J. P. McBride (Massachusetts); Vice Chairmen, C. D. Baucom (North Carolina), S. H. Christie, Jr. (New Jersey), H. J. McDade (San Diego County, California), R. W. Searles (Medina County, Ohio); Treasurer, C. C. Morgan (Gary, Indiana); Chaplain, J. H. Meek (Virginia). The elected officers will serve from the adjournment of the present meeting through the succeeding meeting which will be held June 9 to 13, 1958, in Washington.

[1] *Copies of the* Statement of Organization and Procedure of the National Conference on Weights and Measures *are available on request to the Office of Weights and Measures, National Bureau of Standards, Washington 25, D. C.*

Program Completed for Free Radicals Symposium

TWENTY TECHNICAL PAPERS are scheduled for presentation at a Symposium on the Formation and Stabilization of Free Radicals, to be held at the Bureau on September 18 to 20, 1957. Sponsored jointly by the University of Maryland, the Catholic University of America, the Applied Physics Laboratory of the Johns Hopkins University, and the National Bureau of Standards, the meeting will be devoted primarily to discussions of current research on the properties of systems containing trapped atoms and radicals. This new field of study, now under investigation by laboratories throughout the Nation, is expected to have important applications in both science and engineering.

The program for the meeting is given below. Because of the limited seating capacity of the auditorium, attendance at the Symposium is by invitation, and preregistration is required. Inquiries should be addressed to the Chairman of the Symposium Committee, Dr. A. M. Bass, Free Radicals Research Section, National Bureau of Standards, Washington 25, D. C.

Program for Symposium
on
FORMATION AND STABILIZATION OF FREE RADICALS

Wednesday, September 18, Morning Session. Chairman: Arnold M. Bass, NBS

Francis O. Rice, Catholic University—*Free Radicals: 1900–1957.*
Sidney Golden, Brandeis University—*Free Radical Stabilization in Condensed Phases.*
George Moe, Aerojet-General Corp.—*Research on Free Radicals as Rocket Fuels.*
Barry Commoner, Washington University of St. Louis—*Free Radicals in Biological Systems.*

Wednesday, September 18, Afternoon Session. Chairman: George Porter, the University, Sheffield, England

Norman Davidson, California Institute of Technology—*Experiments on Frozen Free Radicals.*
Robert A. Ruehrwein, Monsanto Chemical Co. and NBS—*Chemical Reactions of Frozen Free Radicals.*
Gabriel J. Minkoff, Imperial College, London, and NBS—*Radical Recombination Reactions at Low Temperatures.*
Bertram Donn, Wayne University and NBS—*The Role of Free Radicals in Astronomy.*

Thursday, September 19, Morning Session. Chairman: F. G. Brickwedde, Pennsylvania State University

George K. Fraenkel, Columbia University—*Paramagnetic Resonance of Free Radicals.*
Walter Gordy, Duke University—*Characteristic Electron-Spin Resonance of Free Radicals Within Solids.*
Ralph Livingston, Oak Ridge National Laboratory—*Studies of Stably Trapped Free Radicals in Solids by Paramagnetic Resonance.*
Roy S. Anderson, University of Maryland—*The Detection and Identification by Electron Spin Resonance Techniques of Free Radicals Trapped in Rigid Matrices.*

Thursday, September 19, Afternoon Session. Chairman: Samuel Foner, Applied Physics Laboratory, Johns Hopkins University

Bernard Smaller, Argonne National Laboratories—*Paramagnetic Resonance Studies of Organic Free Radicals Produced by Gamma Radiation.*
C. K. Jen, Applied Physics Laboratory, JHU—*Free Radicals Trapped at Liquid Helium Temperature and Their Identification by Electron Spin Resonance.*
Samuel I. Weissman, Washington University of St. Louis—*Free Radical Ions of Hydrocarbons.*
Leo Wall, NBS—*Production of Free Radicals by Gamma-rays.*

Thursday Evening: DINNER, Shoreham Hotel, Washington, D. C.

Friday, September 20, Morning Session. Chairman: Paul Giguère, Laval University, Quebec, Canada.

Sidney Leach, University of California—*Matrix Isolation Methdod. Some Studies by Electronic Spectroscopy.*
Donald A. Ramsay, National Research Council, Ottawa, Canada—*The Spectra of Free Radicals in the Gas Phase.*
Kenneth B. Harvey, Laval University and NBS—*Absorption Spectroscopy of Species from Electrical Discharges Condensed at Low Temperatures.*
Herbert P. Broida, NBS—*Free Radical Research at the National Bureau of Standards.*

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TECHNICAL NEWS BULLETIN

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SINCLAIR WEEKS, *Secretary*
NATIONAL BUREAU OF STANDARDS
A. V. ASTIN, *Director*

September 1957 **Issued Monthly** **Vol. 41, No. 9**

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Contents

Publications of the National Bureau of Standards

Journal of Research of the National Bureau of Standards, Volume **59**, No. 2, August 1957 (RP2773 to RP2782 incl.), 60 cents. Annual subscription $4.00.

Technical News Bulletin, Volume **41**, No. 8, August 1957. 10 cents. Annual subscription $1.00.

Basic Radio Propagation Predictions for November 1957. Three months in advance. CRPL–D 156. Issued August 1957. 10 cents. Annual subscription $1.00.

Research Papers

Journal of Research, Volume **59**, *No. 2, August 1957. 60 cents.*

RP2773. A problem in self-heating of a spherical body. S. M. Genensky.

RP2774. Properties of arsenic sulfide glass. Francis W. Glaze, Douglas H. Blackburn, Jerome S. Osmalov, Donald Hubbard, and Mason H. Black.

RP2775. Thermal conductivity of beryllium oxide from 40° to 750° C. David A. Ditmars and Defoe C. Ginnings.

RP2776. A self-balancing direct-current bridge for accurate volometric power measurements. Glenn F. Engen.

RP2777. Some observations on hydrated monocalcium aluminate and monostrontium aluminate. Elmer T. Carlson.

RP2778. Turbidity and viscosity measurements on some cationic detergents in water and in sodium chloride solutions. Lawrence M. Kushner, Willard D. Hubbard, and Rebecca A. Parker.

RP2779. Relative stress-optical coefficients of some National Bureau of Standards optical glasses. Roy M. Waxler and Albert Napolitano.

RP2780. Physical-chemical studies of the destructive alkali-aggregate reaction in concrete. Robert G. Pike and Donald Hubbard.

RP2781. Insulated loop antenna immersed in a conducting medium. James R. Wait.

RP2782. Noncrystal ionic model for silica glass. L. W. Tilton.

Publications in Other Journals

The gassing of dry cells. Earl M. Otto and Woodward G. Eicke, Jr. J. Electrochem. Soc. (Mt. Royal and Guilford Aves., Baltimore 2, Md.) **104**, No. 4, 199–203 (Apr. 1957).

Patents

(The following U. S. Patents have been granted to NBS inventors. Assigned to the United States of America, as represented by the Secretary of the Department noted in parentheses.)

No. 2,787,735. April 2, 1957. Support and housing for electronic circuits. Robert K. F. Seal. (Navy).

No. 2,791,492. May 7, 1957. Apparatus for introducing alkali metal into closed systems. Horace S. Isbell. (Commerce).

No. 2,793,314. May 21, 1957. Long-life gas-filled tubes. John E. White. (Commerce).

No. 2,793,275. May 21, 1957. Photoconductive cell. Robert G. Breckenridge and William Oshinsky. (Army).

No. 2,795,705. June 11, 1957. Optical coincidence devices. Jacob Rabinow. (Commerce).

No. 2,796,416. June 18, 1957. Process of preparing maltobionolactone. Horace S. Isbell and Robert Schaffer. (Commerce).

No. 2,796,522. June 18, 1957. Crystal-controlled relaxation oscillator. Martin Greenspan and Carroll E. Tschiegg. (Commerce).

No. 2,796,756. June 25, 1957. Vibration calibrator. Wilfred A. Yates and Martin Davidson. (Navy).

Publications for which a price is indicated are available only from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. (foreign postage, one-fourth additional). Reprints from outside journals and the NBS Journal of Research may often be obtained directly from the authors.

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